HW #1

#1

$$l = 1.26 \frac{\mu}{\rho\sqrt{RT}}$$

$l = L$

$\mu = ML^{-1}t^{-1}$ $\rho = ML^{-3}$ $R = L^2 t^{-2} \Theta^{-1}$ $T = \Theta$

$$L = 1.26 \frac{(ML^{-1}t^{-1})}{(ML^{-3})\sqrt{L^2 t^{-2} \Theta^{-1} \Theta}} = 1.26 L$$

$$1.26 = \frac{L}{L} = 1$$

The constant is dimensionless

#2

a) $ML^{-2}t^{-2}$

b) Mt^{-2}

c) $ML^{-3}t^{-2}$

d) $ML^{-2}t^{-2}$

#3

$\sigma = \{y\}\{\text{fcn}(M, I)\}$

$ML^{-1}t^{-2} = L\{\text{fun}(M, I)\}$

$\text{fcn}(M, I) = ML^{-2}t^{-2}$

$M = ML^2 t^{-2}$ $I = L^4$

$\sigma = yM\,\text{fcn}(I) \Rightarrow ML^{-1}t^{-2} = L\{ML^2 t^{-2}\}\,\text{fcn}(I)$

$\text{fun}(I) = L^{-4}$

$\sigma = c\frac{My}{I}$ where c = dimensionless

Find C from given data:

$\sigma = 75\ MPa$ $y = 1.5\ in$

$M = 2900\ in \cdot lb$ $I = .4\ in^4$

$$\sigma = 10880\ \frac{lb}{in^2} = C\,\frac{(2900\ in \cdot lb)(1.5\ in)}{.4\ in^4}$$

Solve for C:

$C = 1.00$

$$\boxed{\sigma = \frac{My}{I}}$$

#4

$$F = 3\pi\mu D V + \frac{9\pi}{16}\rho V^2 D^2$$

Assuming constants are dimensionless:

$$MLt^{-2} = \{1\}\{ML^{-1}t^{-1}\}\{L\}\{Lt^{-1}\} + \{1\}\{ML^{-3}\}\{L^2t^{-2}\}\{L^2\}$$

$$= MLt^{-2}$$

Eqn. is dimensionally homogeneous

#5

$$Q = .68\, D^2 \sqrt{gh}$$

$$\{Q\} = L^3t^{-1} = \{.68\}\{L^2\}\{Lt^{-2}\}^{\frac{1}{2}}\{L\}^{\frac{1}{2}} = \{.68\}\{L^3t^{-1}\}$$

$$.68 = \frac{L^3t^{-1}}{L^3t^{-1}} = 1$$

constant 0.68 is dimensionless

#6

Convert to abs. quantities

$T = 75°F = 535°R$

$P = (32\,lb/in^2)(144\,in^2/ft^2) + 2116\,lb/ft = 6724\,lb/ft^2$

$\rho_{air} = \frac{P}{RT} = \frac{6724}{(1717)(535)} = 7.32 \times 10^{-3}\ \frac{slug}{ft^3}$

$W_{air} = \rho \forall g = (7.32\times10^{-3})(3.0)(32.2) = 0.707\ lb$

$\boxed{W_{air} = .707\ lb}$

#7

$\forall = \frac{2}{3}\pi L R^2 = \frac{2}{3}\pi (90)(15)^2 = 42412\ m^3$

Assume given pressures are absolute.

a) $\rho_{helium} = \frac{P_{He}}{R_{He}T} = \frac{1.1(101350)}{2077(293)} = 0.1832\ \frac{kg}{m^3}$

b) $\rho_{air} = \frac{P_{air}}{R_{air}T} = \frac{101350}{287(293)} = 1.205\ \frac{kg}{m^3}$

$W_{He} = \rho_{He}\, g \forall = (.1832)(9.81)(42412) = 76\ kN$

$W_{air} = \rho_{air}\, g \forall = (1.205)(9.81)(42412) = 501\ kN$

$\boxed{W_{He} = 76\ kN}$

$\boxed{W_{air} = 501\ kN}$

Note: the difference $W_{air} - W_{He}$ is the lift force L on the blimp due to buoyancy

$L = 501 - 76 = 425\ kN$